Probe Compensation in Cylindrical Near-Field Scanning: A Novel Simulation Methodology

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Probe pattern compensation is essential in near-field scanning geometry, where there is a great need to accurately know far-field pattern at wide angular range. This paper focuses on a novel formulation and computer simulation to determine the precise need for and effect of probe compensation in cylindrical near-field scanning. The methodology is applied to a linear test array antenna and the NASA scatterometer radar antenna.

The formulation is based on representing the probe (circular aperture) by its equivalent tangential magnetic currents. The interaction between the probe equivalent aperture currents and the test antenna fields is obtained with the application of reciprocity theorem. This allows us to obtain the probe vector output pickup integral which is proportional to the amplitude and phase of the electric field induced in the probe aperture with respect to its position to the test antenna. The integral is evaluated for each probe position on the required sampling point on a cylindrical near-field surface enclosing the antenna. The use of a hypothetical circular-aperture probe with different radius, permits us to derive closed-form expressions for its far-field radiation patterns. These results, together with the probe vector output pickup, allows us to perform computer simulated synthetic measurements. The far-field patterns of the test antenna are formulated based on cylindrical wave expansions of both the probe and test antenna fields. In the limit as the probe radius becomes very small, the probe vector output is the direct response of the near-field at a point, and no probe compensation is needed.

Useful results are generated to compare the far-field pattern (copolar and crosspolar) of the test antenna constructed from the knowledge of the simulated near-field with and without probe pattern compensation and the exact results. These results are important since they clearly illustrate the angular range (in the far-field) over which probe compensation is needed. It has been found that a probe with an aperture radius of 0.25λ, 0.5λ and 1λ needs a little probe compensation if any near the test antenna main beam. In addition, a probe with low directivity shows that at a wider angular range may provide a better signal-to noise-ratio than a highly directive one.